Square shot for faint objects on Hale

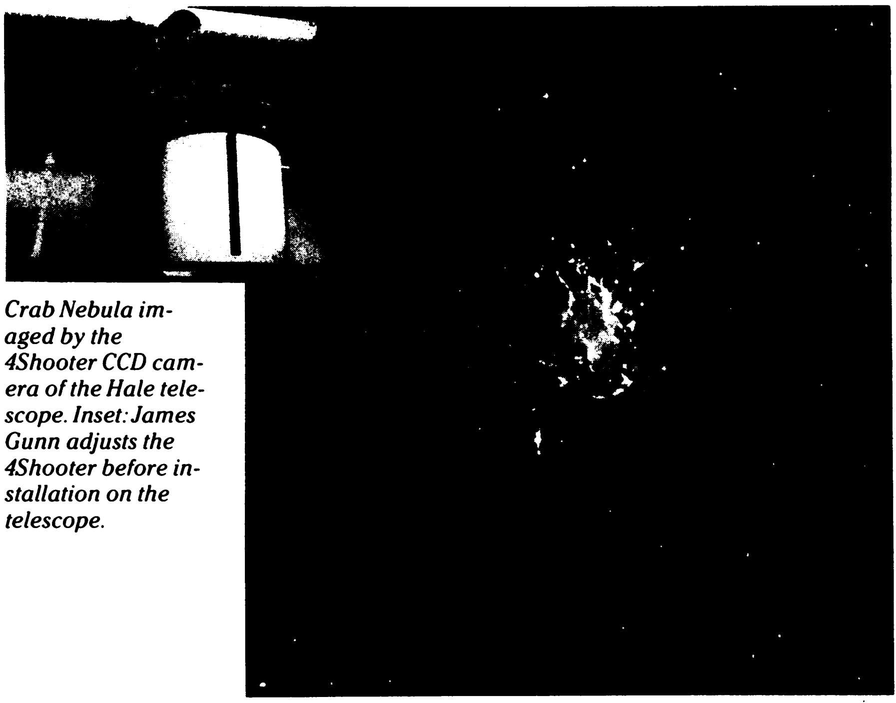
Astronomical information has been recorded and stored in various ways. Among the earliest were written descriptions and sketches — and even the designs and orientations of buildings and monuments. Indeed, at the recent meeting in Baltimore of the American Astronomical Society J.H. Robinson of the University of South Florida in Tampa suggested that Stonehenge was both a memory and a computation device for eclipses. Photographic plates gave astronomers more objective and more complete information recording than sketches and more compact storage than Stonehenge. Today devices that turn the incoming light directly into electronic pulses are becoming popular, especially the charge coupled devices (CCDs).

About three weeks ago, the largest CCD array now in astronomical use, called 4Shooter, went into regular service on the Hale telescope of the Palomar Mountain Observatory in southern California. According to an announcement by the observatory's operator, California Institute of Technology in Pasadena, this makes the Hale telescope "by far the most powerful astronomical instrument in the world."

A CCD is an array of tiny light-sensitive elements arranged in a checkerboard. Light arriving on each element builds up an electric charge on it in proportion to the brightness of the part of the image thrown on it by the telescope's mirrors. Each element becomes a "bucket" of charge — to quote the word most often used by CCD people—and at the end of the exposure the buckets are dumped sequentially into a computer's memory. Not only is this very efficient storage, it is storage in a form that the computer can use directly for making and enhancing images or for calculation.

James Gunn of Princeton University designed and supervised construction of the 4Shooter over a period of four and a half years. It consists of four 800 by 800 unit arrays arranged in a square 1,600 units on a side. A four-faced pyramidal mirror splits the incoming image into four pieces and sends each through focusing optics onto one of the CCD units. The whole thing is housed in a 1.5-ton white cylinder mounted at the Cassegrain focus (that is, just behind the primary 200-inch mirror) of the telescope.

The CCD arrays are identical to those designed for the Space Telescope's Wide Field/Planetary Camera. They were in fact made for that project, but minor flaws made them dubious for use in space but not inappropriate for use on the ground.



Caltech

Crab Nebula imaged by the 4Shooter CCD camera of the Hale telescope. Inset: James Gunn adjusts the 4Shooter before installation on the telescope.

The 4Shooter gives the telescope much greater sensitivity for faint objects. It can image them as faint as 26th magnitude or 200 million times as faint as the faintest the naked eye can see. That seems to be a record for faint imaging. The 4Shooter is twice as sensitive to light as the telescope's previous CCD camera called PFUEI (Prime Focus Universal Extragalactic Instrument) and its field of view, 9 seconds of arc on a side, is three times PFUEI's. This makes it easier to study large objects such as galaxies or clusters of galaxies.

Large telescopes generally have smaller fields of view than most people imagine. With a photographic plate the Hale telescope's field of view is about 20 by 30 minutes of arc. To match it would require a much larger CCD array. They are difficult and expensive to build, and the larger they are, the more problems there are. CCDs originated in a domain of information gathering far less public than academic astronomy, so it would be hard to say for certain that open astronomy is benefiting from the very latest in the technology.

A fifth unit like those in 4Shooter exists and will soon be installed with a spectrographic grating to permit astronomers to take spectra of faint objects. From spectra they can learn about physical and chemical processes in those objects and motions by and within them.—*D.E. Thomsen*

Transferred pea and bean genes work well

Putting a new program into a computer is a snap; getting it to run isn't always so easy. Similarly, it's often simple to put foreign genes into a higher plant or animal, but coaxing the transferred gene to work is harder (SN: 1/29/83, p. 68). Scientists now report two of the first transfers into plants of genes that appear to be regulated correctly — expressed at the right times and in the right tissues — in their new hosts.

Nam-Hai Chua's group at Rockefeller University in New York, and collaborators at MKONSANTO Company in St. Louis, report that a light-activated gene in pea plants works impeccably when put in petunias. The relocated gene not only responds correctly to light, but is active in the light-harvesting chloroplasts of leaf cells, while apparently inactive in stem and root cells, just as in pea plants. "The gene is expressed in a tissue-specific manner," Chua told Science News.

John D. Kemp and Timothy C. Hall at Agrigenetics Corporation in Madison, Wis., say they see correct regulation of the bean gene that encodes phaseolin, a seed storage protein, when they put it in tobacco plants. The gene seems to be strongly expressed in tobacco seeds, but less so in the leaves and stems of these engineered plants.

These experiments are designed to show faithful regulation of transferred genes rather than to "improve" tobacco or petunias. But an understanding of how transferred genes work will be important in engineering agriculturally useful traits in crops, says Georgia Helmer, a plant geneticist at CIBA-GEIGY Corp. in Research Triangle Park, N.C. She predicts that gene segments controlling tissue specificity could be used to direct the activation of transferred genes in particular parts of the plant. Such a system might be used to improve a plant's food value, she says.

Those benefits may be far off, and Chua warns that neither his group's nor Kemp and Hall's data are published.

—*G. Morse*